Farm household risk balancing in Switzerland and Belgium: an econometric and survey approach

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FARM HOUSEHOLD RISK BALANCING IN SWITZERLAND AND BELGIUM: AN ECONOMETRIC AND SURVEY APPROACH

Abstract

This paper presents the first empirical evidence on farm household risk balancing behavior, *i.e.*, making strategic off-farm decisions in response to changes in expected business risk. Firstly, using survey data combined with Flemish FADN data, we construct a psychometric household risk balancing scale and explore what determines the differences in scores for different farm households. Secondly, using Swiss FADN data, we estimate an econometric model that analyzes how farm households jointly alter their levels of debt, off-farm income and consumption. The evidence suggests that in response to exogenous changes in expected business risk, farm households make strategic off-farm decisions. Our study demonstrates that part of the behavioral risk response of farm households is ignored when focusing solely on farm-level analyses and illustrates the relevance of the extended household risk balancing framework.

Keywords

Farm risk, off-farm risk, financial risk, off-farm income, consumption

1. Introduction

This paper presents the first empirical evidence on farm household risk balancing behavior, *i.e.*, farm households making strategic off-farm decisions in response to exogenous changes in expected business risk. The observed unanticipated behavioral responses demonstrate the relevance of the household extension to the original risk balancing framework by Gabriel and Baker (1980).

The original risk balancing framework describes the trade-off between financial risk and business risk in the risk behavior of farmers. Business risk comprises any risk that can be experienced (and managed) at the operational level (e.g., price risk, production risk, institutional risk) and is considered independent from the way the farm is financed. The financial structure of the farm implies additional financial risk stemming from the fixed financial debt obligations. The sum or product of business risk and financial risk constitutes the total farm-level risk. A farmer's risk balancing behavior is characterized by strategic choices of the level of financial risk in response to exogenous changes in expected business risk, keeping the level of total farm risk constant (strong-form risk balancing) or with some observed changes in optimal total farm risk (weak-form risk balancing).

The original risk balancing framework has had several theoretical extensions—most notably the utility-centric model by Collins (1985)—and empirical applications in predominantly US-based research. Wauters, *et al.* (2014) extended the risk balancing framework to the household level by analytically showing that exogenous changes in the farm's business risk position might just as well induce changes in household buffering strategies aside from changes in the level of farm financial risk. It is widely recognized that farm households have several buffering strategies at their disposal that smooth the variation in total household income, including earning off-farm income (e.g. Jetté-Nantel, *et al.*, 2011), smoothing consumption levels (e.g. Mishra, *et al.*, 2002), seeking off-farm investments (e.g. Serra, *et al.*, 2004) or maintaining liquidity buffers (e.g. Remble, *et al.*, 2013). Household risk balancing thus involves strategic changes in any of these buffering strategies in response to exogenous changes in expected business risk while aiming to stabilize total household risk.

This paper will present the first empirical application of the household risk balancing framework using two methodologies. Although many papers have acknowledged the importance of farm household risk exposure and management in European agricultural economics research (e.g. Cafiero*, et al.*, 2007, Vrolijk*, et al.*, 2009, OECD, 2011), empirical applications are limited which is not surprising given that only a few EU member states have the required data on both on-farm and off-farm activities of farm households. Our application analyzes the household risk balancing framework by explicitly recognizing the possibility of simultaneous adoption and the potential correlation between different on- and off-farm responses. This empirical application will make use of (i) data from an extensive survey on the risk experience and behavior of Flemish farmers and (ii) the Swiss farm accountancy data network (FADN) dataset which contains detailed information on farm households' off-farm employment, family composition and consumption levels. Adopting a survey approach for Flanders allowed us to circumvent the problem of data unavailability at the household level. Switzerland—where off-farm data is available—on the other hand is a very interesting case study because off-farm employment opportunities have been readily available to Swiss farmers in recent years and currently off-farm income thus constitutes nearly a third of total household income (FOAG, 2013).

This paper is structured as follows. Section 2 introduces the agricultural production, risk exposure and related policies of our two sample regions. Section 3 discusses the model survey approach and econometric specification of our household risk balancing analysis. Section 4 describes the dataset used combined with the expected regression coefficient signs. The results are presented and discussed in section 5, while section 6 summarizes and concludes.

2. Agricultural production and risk exposure in Belgium/Flanders and Switzerland

2.1 Belgium/Flanders

The relative economic importance of agriculture is limited in Belgium as only 0.7% of the country's GDP in 2012 was provided by agriculture, forestry and fishing (OECD, 2013). However, its importance in total exports was eight times higher (5.8%) and given future environmental and energy challenges its overall importance could increase over time (FOD Economie, 2013).The leading farm structure in Flanders is the small family farm, only 13.7% of the farms were organized as a partnership in 2012; most farms are classified as livestock farms (55%), followed by arable farms (19%), horticulture (13%) and mixed farms (13%) (Departement Landbouw en Visserij, 2013).

Overall income support—*i.e.,* direct payments and rural development schemes—constituted 35% on average over the period 2009–2011, however there were large disparities between farm typologies as support ranged from a low 10% in the fruits, vegetables and floricultural sector to a high 95% for livestock farms.

The availability of recent statistics regarding risk exposure in Flemish agriculture is limited. The volatility of farm income over the period 1990–2003 was found to be high compared to other European countries (Vrolijk*, et al.*, 2009: 39). Lauwers*, et al.* (2009) compare the volatility of yields, prices and gross margins of Flemish farms over the period 1989–2003 and conclude that farm-level volatility is in most instances greater than the volatility measured at sector level. An overview of risk exposure and available risk management instruments in

Flemish agriculture is given by (Deuninck, *et al.*, 2007). The authors conclude that income or revenue insurance is not a priority, yet new production insurances in the crop sector are needed.

2.2 Switzerland

Although the relative economic importance of agriculture is low in Switzerland—0.7% of Switzerland's GDP and below 4% of the employment rate was provided by agriculture in 2011—it is of great importance for the country's rural landscape as farming takes up nearly a quarter of the surface area (OECD, 2013). The dominant farm structure is the small family farm and dairy farms constitute the most prevalent farm typology. Intensive forms of farming are present in the valley region, compared to more extensive systems in the hills and mountain regions.

Swiss agriculture is highly protected, due to several agricultural policy measures in place (e.g. market price support and border protection). Although Switzerland has progressively reduced its support to farmers over time, overall government support remains high. This can be reflected in the high OECD producer support estimates (PSE) at 55% in 2011, which is almost three times the OECD (19%) or EU (17%) average (OECD, 2013). Following a referendum in 1996, the policy objectives of a sustainable agricultural sector that safeguards the rural landscape, conserves resources and adopts environmentally friendly production methods have been anchored into the Swiss constitution (Mann, 2003). Accordingly, in order to be eligible for general direct payments, Swiss farmers have to comply with a set of ecological standards (cross-compliance). In addition, several alternative ecological and animal welfare direct payments are available on a voluntary (compensated) basis.

A consequence of the high level of government protection and support is that Swiss farmers are less exposed to market price risk than their colleagues in neighboring countries and also makes them less vulnerable to climate volatility (Lehmann, *et al.*, 2013). Accordingly, Swiss agricultural gross revenues and household incomes are rather stable (El Benni, *et al.*, 2012). Regardless of the high level of income support, however, Swiss farmers do earn a lower income compared to other industries. For the 2010-2012 period, agricultural incomes reached between 41% (mountainous region) to 66% (plain region) of the comparable income earned in the industry or service sectors (Schmid and Roesch, 2013). Lips, *et al.* (2013) show for Swiss dairy farms that farmer's family members earn double the on-farm income per full-time employee when they work off-farm. The income composition of Swiss farm households has also changed over the last years: between 2003/04 and 2010/10 the agricultural income was almost stable at CHF 57,500, yet at the same time the off-farm income increased by 34% reaching CHF 20,000 (Lips and Schmid, 2013). The question arises, however, whether this increased reliance on off-farm income involves a risk-reduction strategy.

3. Methodology

3.1 Survey analysis approach

Our first approach to empirically assess household risk balancing behavior consist of constructing a psychometric scale based on survey questions (details regarding the survey design will be discussed in section 4.1 and in the Appendix). In order to elicit a proxy for household risk balancing behavior, we asked the following set of nine questions in a questionnaire survey:

Q1: My partner and/or I would like to obtain an off-farm income

Q2: We cut private expenses when the farm has a financially rough time

Q3: Important farm investments are always discussed with the whole family (spouse, children) and their opinion weighs in on the final decision

Q4: I am reluctant to make farm business decisions that might jeopardize our family income

Q5: I do not distinguish between a private and business bank accounts

Q6: Sometimes money from our private account is used to repay farm business loans

Q7: In times of low farm income, private expenses are postponed

Q8: Off-farm income is essential for the farm household to make ends meet

Q9: Sometimes money from our private account is used to pay farm business bills

Farmers were asked to indicate their level of agreement with these statements, on a scale ranging from 1 (totally disagree) to 5 (totally agree). The psychometric household risk balancing scale was constructed using a formative scale, accordingly a change in the construct is not necessarily associated by an equivalent change in each sub-dimension of the construct (Podsakoff, *et al.*, 2003). Based on the theoretical model from Wauters, *et al.* (2014), household risk balancing is defined as a behavior that is characterized by four sub-dimensions: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) the necessity of off-farm income and (iv) mixing personal and business bank accounts to cover expenses. The first three dimensions were measured using two items (respectively: Q3 and Q4; Q2 and Q7; Q1 and Q8), the latter using three items (Q5, Q6 and Q9). Each of these subscales were considered reflective measurement scales, meaning that the items are manifestations of the underlying construct and a change in the construct is believed to cause a change in all items of the measurement scale (Edwards and Bagozzi, 2000). The reliability of each separate dimension (*i.e.*, whether they measure the same concept) was assessed with confirmatory factor analysis using maximum likelihood and varimax rotation and validated using Cronbach alpha values. The values of each sub-dimension were calculated as the mean of the individual item scores. Because each dimension was considered equally important in defining the overall household risk balancing construct, the composite index was calculated as the mean of all sub-dimensions.

To investigate the differences in our household risk balancing behavior scale, we estimate a simple cross-sectional linear regression model:

$$HHRB_i = \alpha + \beta X_i + \varepsilon_i \qquad (1)$$

where *i* indexes farms, *HHRB* represents our household risk balancing scale, *X* is a set of off-farm, farm operator and farm related covariates, α represents the intercept, β is a vector of coefficients to be estimated and ε is the idiosyncratic error term. Model 1 can be readily estimated using OLS.

3.2 Econometric model specification

Our second approach to evaluate household risk balancing behavior is based on estimating an econometric model using observed farm and off-farm data from the Swiss FADN dataset. Risk balancing behavior entails strategic decisions in response to exogenous changes in the expected level of business risk. The original Gabriel and Baker (1980) risk balancing framework focusses solely on financial responses (*i.e.*, changes in the level of debt), whereas the extended household risk balancing framework goes beyond the original framework by also considering strategic off-farm responses. These responses include changes in off-farm income, consumption levels, off-farm investments or liquidity buffers that determine the level of off-farm risk. Given the unavailability of data for the latter two responses in the Swiss FADN dataset, we will focus on off-farm income and consumption. We further assume that farmers form their expectations of future business risk based on past exposure to business risk (Hardaker, *et al.*, 2004: 62).

Our overall regression rationale to analyze household risk balancing is thus regressing changes in past levels of business risk on three strategic decisions made by the farm household: (i) the level of financial risk, (ii) the amount of off-farm income earned and (iii) farm household consumption. We expect to find a negative relationship for financial risk in line with the original risk balancing hypothesis (increased expected business risk results in lowered financial risk). Consistent with household risk balancing, we would expect farm households to lower off-farm risk in response to an increase in expected business risk by acquiring more off-farm income (positive relationship) and smoothing consumption levels (negative relationship). We further control for several additional risk balancing, farm(er) and household related characteristics based on literature. The definitions and expected signs of these regressors will be discussed in section 4.2.

First, we look at the original risk balancing hypothesis and estimate the following two-way fixed effects model:

$$FR_{i,t} = \beta_{BR}(BR)_{i,t-1} + \beta x_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{2}$$

where i and t are indexing farm and year, FR represents our dependent variable financial risk, BR characterizes our main variable of interest business risk and its β_{BR} associated coefficient, β represents the coefficient vector of the explanatory variables x elaborated above and μ, λ and ε symbolize the farm-specific, year-specific and idiosyncratic error terms respectively. By estimating a fixed effects regression model, we make use of the panel structure of our dataset to account for unobserved heterogeneity that varies across farms but does not change over time and vice versa. Note that due to using lagged values of business risk (to represent expectations) it is considered purely exogenous.

Next, we look at household risk balancing by considering the three following equations that reflect strategic responses to exogenous changes in business risk:

$$FR_{i,t} = \beta_{BR,1}(BR)_{i,t-1} + \beta_1 X_{i,t,1} + \mu_{i,1} + \lambda_{t,1} + \varepsilon_{i,t,1} \tag{3}$$

$$OFI_{i,t} = \beta_{BR,2}(BR)_{i,t-1} + \beta_2 X_{i,t,2} + \mu_{i,2} + \lambda_{t,2} + \varepsilon_{i,t,2} \tag{4}$$

$$CONS_{i,t} = \beta_{BR,3}(BR)_{i,t-1} + \beta_3 X_{i,t,3} + \mu_{i,3} + \lambda_{t,3} + \varepsilon_{i,t,3} \tag{5}$$

where *OFI* and *CONS* represent our dependent variables off-farm income and consumption, all other symbols are defined as before and the subscripts 1, 2 and 3 are introduced to refer to the financial risk, off-farm income and consumption equations respectively.

Although these three equations can be estimated separately and consistently by OLS, there are gains in efficiency (*i.e.*, lower standard errors) to be obtained if they are estimated jointly using SUR—seemingly unrelated regressions (Zellner, 1962)—or 3SLS–three stage least squares (Zellner and Theil, 1962)—methods. Additionally, these methods allow for testing of cross-equation restrictions. The SUR model corrects for contemporaneous correlation of the error terms, while in the case of 3SLS the dependent variables also appears as endogenous regressors in the other equations. As our three equations represent decisions made by the same entity (the farm household), they cannot be considered autonomous and hence 3SLS estimates would not make sense and SUR is the most appropriate system estimation methodology (Wooldridge, 2010: 239). Indeed, the *ceteris paribus* parameter estimates of business risk in a three-equation system modeling one strategic decision in terms of the others and vice versa would have no sensible economic meaning. Household risk balancing prescribes that a farm household simultaneously changes financial risk, off-farm income and consumption levels, hence we have no reason to hold any of the other responses fixed. Given the preceding arguments, we will estimate equations 2 to 4 in a system of seemingly unrelated regressions (SUR) which captures the efficiency by modeling the correlation of the disturbances across equations. We account for the panel structure of the dataset by manually applying a within transformation to the data (*i.e.,* subtracting the within-farm mean from each variable).

One potential problem when following a SUR approach is the presence of heteroskedasticity, which leads to inconsistent estimates. Therefore, we will also estimate our system of equations using what Wooldridge (2010: 219) calls the 'GMM 3SLS' estimator that extends the traditional 3SLS system estimator by taking heteroskedasticity into account using an optimal weight matrix. Furthermore, the estimator allows different instruments for different equations to be specified. As all the regressors in our model are exogenous, we specify the equation-specific regressors X_1, X_2 and X_3 as instruments, hence reducing the 3SLS estimator to the SUR estimator.

Note that the relationships expressed by equations 3, 4 and 5 are static models that assume that adjustments are made in the short run. However, adjustments to the financial risk position or to off-farm income streams are not necessarily made in the short run and consumption could be smoothed over longer periods of time. Capturing these effects would require a dynamic model formulation of this system of three equations where lagged dependent variables are included on the right hand side of the equations. To the best of our knowledge, however, a dynamic panel estimator (e.g. difference GMM or system GMM) allowing the simultaneous estimation of three equations does not exist. Therefore, in order to make use of a system estimator (to gain efficiency and test cross-equation restrictions) we focus on a static formulation ignoring potential dynamic or long run effects.

4. Data and descriptive statistics

4.1 Survey analysis approach

First, we make use of survey data from an extended 2013 questionnaire survey that was aimed at understanding the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of Flemish farmers (n = 614). Details regarding survey design and data collection can be found in Appendix A2. The respondents were the farmers from the Flemish regional version of the FADN dataset which is collected and analyzed by the Flemish government (De Becker, 2007). This connection allows us to complement the information from our 2013 survey with farm and farm operator related variables of the 2012 FADN sample (2013 data was not yet available at the time this study was conducted) to estimate model 1 from section 3.1.

The construction of the dependent variable *household risk balancing* was previously discussed in section 1. A set of off-farm, farm operator and farm characteristics was selected as independent variables to investigate differences in household risk balancing behavior.

Off-farm activity is a dummy variable from the FADN dataset indicating whether the farm operator or his/her spouse spend time on an off-farm activity for at least one day per week. As information regarding *off-farm income* is not present in the Flemish FADN dataset, farmers were asked to indicate the percentage of total household income that is gained from off-farm sources. Another survey question inquired how variable total household income was over the past five years, which was termed *total household risk*. To distinguish smaller family farms from larger commercial farms, we constructed the dummy variable *employees* that takes the value of one when a farm has paid employees.

To characterize the risk attitude of the farm operator, we constructed a psychometric *risk aversion* scale based on nine survey questions. Detailed information regarding its construction can be found in the Appendix A2. *Age* is the age of the farm operator as reported in the 2013 survey. Two educational categorical dummies indicate the *education type* (none = reference level, agricultural, non-agricultural) and *educational level* (middle school or none = reference level, high school, undergraduate, graduate or other) of the farm operator as indicated in the FADN dataset.

To characterize the financial situation of the farm, the rate of return on assets (*ROA*), the share of subsidies received in total revenue (*subsidy ratio*) and solvability (*debt/assets*) were calculated from the FADN data. *Partnership* is a dummy variable indicating the legal status of the farm and takes the value of one when the farm business is organized in a formal partnership. We further account for differences in *farm typology* based on the 8 broad farming types defined in the FADN dataset. Farm cycle is a categorical survey variable indicating whether a farm is (i) starting out, (ii) established and growing, (iii) established and stable (reference level), (iv) preparing a takeover or (v) is winding down for retirement. Size class is a categorical dummy distinguishing small, medium and large farms based on standard output (a criterion of the economic size of a holding).

The final sample of farms available for analysis—*i.e.*, that does not have missing values for any of the variables elaborated above—consists of 441 observations, which is 72% of all surveyed farmers. Summary statistics of the variables used in the survey approach of this paper can be found below in Table 1.

Table 1 Summary statistics for the Flemish FADN dataset complemented with survey data

Variable	Mean	Stdev.	Unit
Dependent variable			
Household risk balancing	3.36	0.65	Scale
Off-farm elements			
Off-farm activity operator[a]	0.07	0.26	Dummy
Off-farm activity spouse[a]	0.29	0.46	Dummy
Off-farm income	0.22	0.24	%
Total household risk	3.58	1.13	Scale
Employees[a]	0.34	0.48	FTE
Farmer related			
Risk aversion	3.22	0.59	Scale
Age	48.54	8.39	Years
Education type[a]			Categorical
None	0.00		
Agricultural	0.61		
Non-agricultural	0.38		
Educational level[a]			Categorical
Middle school or none	0.02		
High school	0.82		
Undergraduate	0.12		
Graduate	0.03		
Other	0.01		
Farm related			
ROA[a]	0.15	0.13	%
Subsidy ratio[a]	0.07	0.06	%
Debt/Assets[a]	0.28	0.22	%
Partnership[a]	0.16	0.36	Dummy
Farm typology			Categorical

Specialist field crops	0.09	
Specialist horticulture	0.17	
Specialist permanent crops	0.09	
Specialist grazing livestock	0.28	
Specialist granivore	0.17	
Mixed cropping	0.02	
Mixed livestock	0.09	
Mixed crops-livestock	0.10	
Farm cycle		Categorical
Starting out	0.02	
Established and growing	0.27	
Established and stable	0.60	
Preparing takeover	0.03	
Winding down for retirement	0.07	
Size Class		Categorical
Small	0.26	
Medium	0.36	
Large	0.39	

Notes: [a] Data from the 2012 FADN dataset, all other variables were collected in a 2013 survey; N = 441

4.2 Econometric approach

Our econometric approach makes use of the Swiss farm accountancy data network (FADN) dataset, which is collected and analyzed by Agroscope Reckenholz–Tänikon Research Station ART (Schmid and Roesch, 2013). The comprehensive database includes detailed information based on cost accounting and covers 10 years from 2003 to 2012. An unbalanced panel dataset is compiled from this source by selecting those farms that (i) do not have missing values for the key variables needed for estimation (ii) are present in the dataset at least four consecutive years (to calculate the lagged value of business risk, which in turn is calculated over 3 years), (iii) have a positive farm income (given the problematic calculation of the coefficient of variation of negative values) and (iv) do not present outlying values. The following observations were considered as outliers: financial risk measures greater than one, implausible consumption levels (*i.e.*, negative or extravagant (for 2 observations 10-fold higher compared to the previous period)), negative values of interest paid or ROA and extreme level of farm income (for 1 observation 10-fold higher compared to the previous period). Our final regression sample contains 12,827 observations (41% of the original data) covering 3,184 farms (55% of the original farms), 23.4% of which are present the entire period.

The three main dependent variables in the econometric analysis of this paper are financial risk, off-farm income and consumption. In line with Gabriel and Baker (1980), *Financial risk* is measured as the ratio of interest paid over farm income. Farm income represents the remuneration of family owned capital, labor and land and is calculated by subtracting intermediate costs, depreciation, wages paid, rent paid for land and interest paid from gross revenue including subsidies and taxes. Financial risk reflects the level of risk chosen by the farm household, *i.e.*, when the share of income spent on interest payments is high, farm households choose to have more financial risk as the margin to pay off their debt is lower and they are also more exposed to interest rate risk. *Off-farm income* comprises all income sources earned off-farm that are actively chosen by the farm household: wages earned by self-employment, wages earned by employment and income from investments. These income sources account for 60% of total reported off-farm income on average and exclude sources such as social transfers, pensions or inheritances that farm households do not actively choose themselves. *Consumption* measures the total monetary level of consumption of the family members living on the farm (it includes the categories insurance costs, car costs, housing costs, social contributions and other consumption including food expenditures).

Our main independent variable of interest, *business risk* (BR), is represented by the coefficient of variation of farm income before interest payments. We thus define risk in terms of the variability of outcomes and assume that farmers form their expectations of future business risk based on past levels of variation in income. Note that observed past level of variation only represent part of the potential risk that farmers faced. Furthermore, by taking risk management actions, they potentially reduced risk, creating an additional difference between potential and observed variation. The coefficient of variation is calculated over a moving 3-year window. The 3-year period was chosen because business risk measures calculated over 4-year and 5-year periods were highly correlated (80%) with the 3-year measure. Hence, in order to retain as much observations as possible (recall that our dataset is unbalanced), we only considered 3-year measures. For our descriptive results in section 5.2, we additionally calculated *total farm risk* (TR_f) as the 3-year coefficient of variation of farm income and total household risk (TR_h) as the 3-year coefficient of variation of household income, which is simply the sum of farm income and off-farm income.

The original risk balancing related independent variables are past values of the cost of debt, profitability and liquidity. The cost of debt is represented by the *interest percentage* paid on loans (interest paid over total outstanding debt). Profitability is measured by the rate of return on assets (ROA), calculated as the ratio of farm income over total assets. Liquidity is characterized by the monetary value of *current assets*. In our financial risk equation, we expect to find a negative relationship with past levels of profitability and a positive relationship with past levels of debt costs and liquidity (Gabriel and Baker, 1980).

The off-farm elements considered in this paper are the existence of extra off-farm income, the units of consumption, the amount of children and the educational level of the farm operator.

OFI incomplete is a dummy variable indicating whether additional off-farm income earned by the farm household was not completely reported under off-farm income. This variable mainly acts as a control variable, it should clearly be positively related to off-farm income and consumption.

The amount of *consumption units* (UC) represents the standardized number of family members in the farm household. The householder accounts for one UC, other family members of 14 years or older account for 0.5 UC and 0.3 UC for children below the age of 14. Aside from an obvious positive influence on consumption, we would also expect a positive influence of household size on off-farm income as larger farm families can more easily share the on-farm work—making more time available for off-farm work—and potentially have some family members willing to fully work off-farm (Mishra and Goodwin, 1997, Goodwin and Mishra, 2004). The variable *children -16* additionally counts the number of children below the age of 16 that are part of the farm household. This variable captures the effect of having a higher composition of children in the household as we also control for the amount of UC. Accordingly, we expect a negative influence on off-farm income as children below the age of 16 are considered too young to work and a positive influence on consumption as having more children tends to increase the required household budget.

An educational dummy represents whether the farm operator has had some form of household-related or nonagricultural *education* (e.g. an apprenticeship, a professional training, a mastercraftship or training at a technical college or university) or is currently in education. Having a formal education increases the amount of off-farm jobs available and hence potentially increases the amount of off-farm income that can be earned (Woldehanna, *et al.*, 2000, Alasia, *et al.*, 2009).

The farm(er) related variables considered in this study are direct payments, farm size, land tenure, age, farm income, liquidity and equity.

In our financial risk model, *% Direct payments* represents the share of direct payments received in total gross revenue. This alternative formulation was chosen to prevent multicollinearity problems with farm size as direct payments are tied to farm area. This form of government support can be considered as a stable and thus low-risk income source. In that sense, they would allow farmers to increase debt usage in line with the original risk balancing hypothesis. In the off-farm income and consumption regression, *direct payments* simply represent the monetary amount of direct payments received. Previous research has suggested that government subsidies (coupled or decoupled) reduce off-farm labor participation (Serra, *et al.*, 2005, Ahearn, *et al.*, 2006). Therefore we would expect a negative influence of direct payments on off-farm income obtained in addition to a logical positive influence on consumption levels.

Farm size measures the total *area* of the farm used for production in hectares. Previous research has suggested a positive relationship with debt usage and negative with off-farm income (Fernandez-Cornejo, 2007, Alasia, *et al.*, 2009). Larger farms potentially have higher consumption levels due to economies of scale allowing for increased income per family member.

Land *tenure* represents the percentage of land under tenure of the farm household and is measured as the ratio of owned land over total farm size. As agricultural land prices are generally high in Switzerland (e.g. Giuliani and Rieder, 2003), we expect farm households who own a larger percentage of their land to have higher debt usage and would be motivated to gain more off-farm income.

Age is the age of the farm operator and age^2 was also included in our models to account for potential second-order effects. We expect younger farmers to have larger levels of financial risk, yet also that they prefer to decrease investments and pay off their debts as they become older. Accordingly, we expect a concave down function and hence a positive age and negative relationship age^2 coefficient. The relation with off-farm income is less clear to predict a-priori, however, as older farmers might have more difficulties finding an off-farm job (Goodwin and Mishra, 2004), but this potential decrease in hours worked off-farm might be compensated by increased hours worked on-farm and therefore complemented with off-farm income gained by the other household members.

We anticipate that farm households with low amounts of *farm income* compensate by gaining more off-farm income (and vice-versa) and that getting more farm income has a positive influence on consumption levels.

To take the typical consumption-saving tradeoff into account, we include the monetary amount of current assets as a proxy for savings in absence of more detailed information regarding the savings behavior of the farm households (assuming that part of the yearly amount saved ends up under current assets in the balance sheet as cash on a checking or savings account).

Finally, we include equity as a proxy measure to take differences regarding household wealth into account. *Equity* represents the monetary amount of assets owned privately by the farm household (note that no clear distinction is made in the dataset between farm equity and farm household equity) and is expected to have a positive influence on consumption levels.

Note that all monetary variables are deflated using the CPI constructed by the Swiss Federal Statistical Office (available online at http://www.bfs.admin.ch). Summary statistics of the variables used in the econometric approach can be found in Table 2.

Table 2 Summary statistics for the Swiss FADN dataset

Variable	Mean	Std. Dev.	Unit
Dependent variables			
Financial risk (FR)	0.13	0.15	Ratio
Off-farm income (OFI)	1.42	2.26	10^4 CHF
Consumption (CONS)	7.34	2.64	10^4 CHF
Risk balancing			
Business risk (BR)	0.21	0.15	Coefficient of variation
Interest%	1.93	2.18	%
Return on Assets (ROA)	0.09	0.07	Ratio
Current Assets	1.22	0.93	10^5 CHF
Off-farm elements			
OFI Incomplete	0.25	0.43	Dummy
Consumption Units (UC)	3.52	1.46	UC
Children -16	1.05	1.35	Children
Education	0.10	0.30	Dummy
Farm(er) related			
Direct Payments	6.06	2.76	10^4 CHF
% Direct Payments	0.26	0.13	Ratio
Area	25.61	12.83	Ha
Tenure	0.64	0.28	Ratio
Age	48.21	8.37	Years
Farm Income	6.91	4.03	10^4 CHF
Equity	5.33	3.51	10^5 CHF

Notes: All monetary values deflated to 2012 values using the Swiss Federal Statistical Office CPI (http://www.bfs.admin.ch), N = 12,827

5. Results and discussion

5.1 Survey evidence on household risk balancing behavior

First, using confirmatory factor analysis, we find that the reflective measurement scales for the four household risk balancing sub-dimensions show adequate reliability. Taking decisions as a family, adjusting private expenses and adjusting off-farm income streams had 2 items each, with no items having a lower factor loading than 0.5. Mixing the private and business account had 3 items, all with factor loadings above 0.50. Second, the value of the sub-dimensions were calculated as the mean of all items for each sub-construct. Third, we calculated the composite household risk balancing construct as the average of each of these four sub-constructs. The mean value is 3.36 on a scale ranging from 1 (absolutely no household risk balancing behavior) to 5 (substantial household risk balancing behavior), suggesting that the average Flemish farm household exhibits household risk balancing behavior (Table 3). About two thirds of the sample (64%) has a value greater than the neutral level 3.

Table 3 Survey construct of household risk balancing behavior

(Sub-)Factor	Average (Std. Dev.)
Aggregate construct	3.36 (0.647)
Sub-dimensions	
Decisions in family	3.80 (0.781)
Delay/reduction in private spending	3.77 (0.923)
Mixing farm and private accounts	3.13 (1.174)
Necessity of non-farm income	2.73 (1.236)

Notes: N = 441

Table 4 presents the parameter estimates of model 1 that investigates the differences in the household risk balancing behavior scale from Table 3 There is no indication of multicollinearity problems in the data (variance inflation factors (VIF) of all regressors are between 1 and 2), nor is heteroskedasticity present (insignificant Breusch-Pagan/Cook-Weisberg heteroskedasticity test at $\alpha = 0.01$).

We find that farm operators that have an off-farm activity for at least one day per week and farm household where a larger proportion of total household income is earned off-farm, score greater on our household risk balancing scale; a sensible result as pursuing off-farm activities is part of our scale construction. Interestingly, farm households that indicate to have experienced high volatility in their household income over the past five years have greater household risk balancing scores. This finding suggests that for those families, households risk balancing could be a viable risk management option. We do not find a significant difference in household risk balancing behavior between small scale family farms versus larger scale commercial holdings.

Table 4 Parameter estimates for the determinants of the household risk balancing decisions made by Flemish farm households in 2013

Variable	Coefficient	(SE)
Off-farm aspects		
Off-farm activity operator[a]	0.2405**	(0.1049)
Off-farm activity spouse[a]	0.0549	(0.0642)
Off-farm income	0.5810***	(0.1283)
Total household risk	0.1718***	(0.0238)
Employees[a]	0.0231	(0.0737)
Farm operator		
Risk aversion	0.3365***	(0.0466)
Age	0.0038	(0.0040)
Education type[a]		
Agricultural	-0.5741	(0.5867)
Non-agricultural	-0.5270	(0.5855)
Educational level[a]		
High school	0.0551	(0.2270)
Undergraduate	-0.0069	(0.2401)
Graduate	-0.0936	(0.2668)
Other	-0.2645	(0.3281)
Farm		
ROA[a]	-0.5141**	(0.2396)
Subsidy ratio[a]	0.4802	(0.6816)
Debt/Assets[a]	0.3046**	(0.1410)
Partnership[a]	0.0390	(0.0737)
Farm typology		
Specialist field crops	-0.1731	(0.1072)
Specialist horticulture	-0.1193	(0.1149)
Specialist permanent crops	0.0224	(0.1438)

Specialist granivore	-0.0564	(0.1044)
Mixed cropping	-0.0302	(0.2136)
Mixed livestock	-0.0767	(0.1086)
Mixed crops-livestock	0.0318	(0.0972)
Farm cycle		
Starting out	-0.0278	(0.1899)
Established and growing	0.0593	(0.0659)
Preparing takeover	-0.0184	(0.1471)
Winging down for retirement	0.0714	(0.1080)
Size Class		
Small	0.0061	(0.0725)
Large	-0.0179	(0.0677)
Constant	1.7802***	(0.6091)
F	7.9***	
R^2 adjusted	0.3230	

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01; reference levels for the categorical variables are specialist grazing livestock, established and stable and medium respectively; N = 441

In the group of farm operator related variables, we find that more risk averse operators exhibit significantly greater household risk balancing behavior.

We observe that less profitable and more leveraged farms—as measured by the rate of return on assets and the debt over assets ratio—perform more household risk balancing. Having low profitability and high levels of financial risk leads to higher farm-level risk. Our finding is thus in line with theory that in this case we would expect (more) household risk balancing behavior to buffer the elevated farm-level risk. Finally, we do not find any significant differences with regard to the farm's legal structure, typology, farm cycle or size class.

5.2 Risk exposure in Swiss agriculture over time, region and farm typology

Figure 1 presents the volatility of the average levels of total farm risk, business risk and total household risk over the period 2005–2012. The general risk exposure—as measured by coefficients of variation between 0.20 and 0.25—in Swiss agriculture is low compared to other countries. de Mey, *et al.* (2014) report the EU-15 average farm-level business risk at 0.33 (1995–2008), while Poon and Weersink (2011) report average levels of total farm risk of as high as 3.8 for Canada (2001–2006). Overall, there is little year-to-year variation in the average levels of risk, barring a small surge in the year 2010. The later can be explained by recalling that we calculate risk over three-year periods, hence the 2010 risk measure spans the years 2008–2010, a period characterized by elevated prices for arable crops and milk, followed by a marked drop (Schmid and Roesch, 2013). The difference between business risk and total farm risk represents financial risk and the difference between total farm risk and total household risk represents off-farm risk. Whereas financial risk increases total farm risk relative to business by definition, off-farm risk can either stabilize or increase total household risk compared to total farm risk. On average, the relationship is a stabilizing one (average total household risk is lower than total farm risk), yet for 24% of the observations household-level risk is higher than farm-level risk.

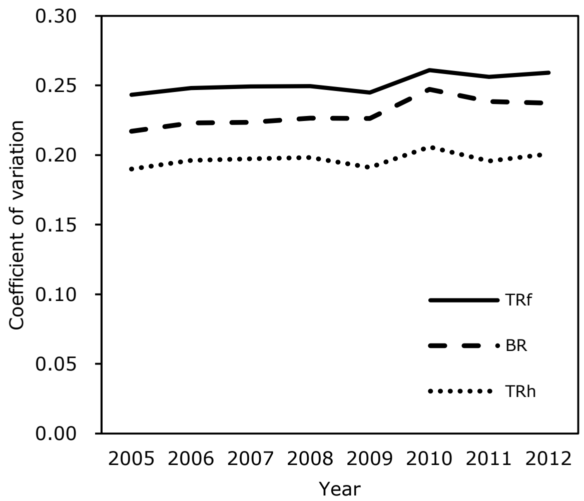

Figure 1 Comparison over time of average total risk at the farm level (TR_f), business risk (BR) and total risk at the household level (TR_h)

Table 5 compares the same risk measures from Figure 1 over farm typology and across the three distinct production regions in Switzerland. Four typologies were considered; dairy farms as these constitute the predominant farm type in Switzerland, and three general classes: mixed farms, crop based and animal based farms (other than dairy). We observe that the crop and animal based production types have above average levels of risk. A closer inspection of the data revealed that this is mainly accounted for by arable farms and pig farms, which are particularly susceptible to production risk (weather influences) and price risk (the hog cycle), respectively. Conversely, dairy farms have below average risk levels, which could be attributed to relatively stable milk prices—compared to the price volatility for crops and pork—and a higher share of direct payments. Differences across the production regions are less pronounced. One noticeable result is that the valley region has above average risk levels, as this is the region with most arable and pig farms and furthermore the share of direct payments in the farm's turnover increases with the altitude.

Table 5 Comparison over farm typology and region of average total risk at the farm level (TR_f), business risk (BR) and total risk at the household level (TR_h)

	TR_f	BR	TR_h	N
Farm Type				
Dairy	0.217	0.193	0.168	5,109
Mixed	0.247	0.221	0.199	5,008
Crops	0.268	0.234	0.190	1,784
Animals	0.253	0.234	0.200	926
Region				
Valley	0.244	0.219	0.199	5,639
Hill	0.232	0.205	0.178	3,985
Mountain	0.237	0.210	0.171	3,203
Total	0.239	0.213	0.185	12,827

Notes: The Swiss FADN distinguishes 11 types of farms (Hoop and Schmid, 2013). These types were classified as follows: dairy (21), mixed (51 to 54), crops (11 and 12) and animal (22, 23, 31 and 41)

5.3 Econometric evidence on farm-level and household-level risk balancing behavior

Table 6 presents the parameter estimates of our fixed effects (FE), seemingly unrelated regression (SUR) and generalized method of moments (GMM) models. All econometric models were estimated using the statistical package Stata (StataCorp, 2011). There is no indication of multicollinearity problems in the data, the variance inflation factors (VIF) of all regressors are between 1 and 2. We have reason to assume heteroskedasticity is present, as a modified Wald test for groupwise heteroskedasticity in fixed effects models (Greene, 2003: 598) for each individual equation indicated the presence of farm-specific error variances (α = 1%). We therefore clustered our standard errors by farm in the FE model and will compare our SUR model results with the heteroskedasticity robust GMM model results.

Table 6 Parameter estimates for the determinants of the financial risk (FR), off-farm income (OFI) and consumption (CONS) decisions made by Swiss farm households for the period 2006–2012 using fixed effects (FE), seemingly unrelated regression (SUR) and generalized method of moments (GMM) models

	FE	SUR			GMM		
	FR	FR	OFI	CONS	FR	OFI	CONS
Risk balancing							
BR_{t-1}	-0.0131	-0.0133**	0.2184***	-0.2107**	-0.0130	0.2191***	-0.2083**
	(0.0103)	(0.0061)	(0.0674)	(0.0913)	(0.0085)	(0.0689)	(0.0991)
Interest% $_{t-1}$	-0.0314	-0.0003			-0.0003		
	(0.0231)	(0.0004)			(0.0002)		
ROA $_{t-1}$	-0.1897***	-0.1964***			-0.1897***		
	(0.0307)	(0.0242)			(0.0247)		
Current Assets $_{t-1}$	0.0060*	0.0055***			0.0060**		
	(0.0031)	(0.0017)			(0.0024)		
Off-farm elements							
OFI Incomplete			0.2161**	0.2294*		0.2159***	0.2236**
			(0.0885)	(0.1198)		(0.0816)	(0.1015)
UC			0.0143	0.1720***		0.0143	0.1725***
			(0.0152)	(0.0205)		(0.0135)	(0.0230)
Children -16			-0.0719***	0.0494**		-0.0718***	0.0502**
			(0.0162)	(0.0219)		(0.0194)	(0.0228)
Education			-0.1087			-0.1277	
			(0.1201)			(0.1236)	
Farm(er) related							
% Direct Paym.	0.5055***	0.5128***			0.5055***		
	(0.0435)	(0.0252)			(0.0336)		
Area	-0.0012**	-0.0012***			-0.0012**		
	(0.0006)	(0.0004)			(0.0005)		
Tenure	0.1305***	0.1303***	0.1882	0.2035	0.1305***	0.1876	0.1937
	(0.0211)	(0.0137)	(0.1491)	(0.2020)	(0.0160)	(0.1249)	(0.2314)
Age	0.0056*	0.0055**	0.1161***	0.2262***	0.0056**	0.1161***	0.2272***
	(0.0034)	(0.0024)	(0.0278)	(0.0376)	(0.0025)	(0.0312)	(0.0445)
Age^2	-0.0001	-0.0001**	-0.0013***	-0.0023***	-0.0001**	-0.0013***	-0.0024***
	(0.0000)	(0.0000)	(0.0003)	(0.0004)	(0.0000)	(0.0003)	(0.0004)
Direct Payments			-0.0623***	0.0673***		-0.0625***	0.0657***
			(0.0133)	(0.0180)		(0.0158)	(0.0236)
Farm Income			-0.0268***	0.0874***		-0.0275***	0.0818***
			(0.0040)	(0.0054)		(0.0051)	(0.0088)
Current Assets			0.1083***	-0.0708***		0.1083***	-0.0710*
			(0.0185)	(0.0250)		(0.0284)	(0.0417)
Equity			0.0082	0.0183		0.0081	0.0179
			(0.0099)	(0.0134)		(0.0148)	(0.0190)
Constant	-0.1643*						
	(0.0921)						
F test statistic	19.3***						
R^2 within	0.0489						
Chi^2 test statistic		674***	398***	548***			
R^2		0.0489	0.0303	0.0383			
Wald test BR_{t-1}= 0			$\chi^2(3)$ = 21.46***			$\chi^2(3)$ = 18.2***	

Notes: Year dummies were included in each model but not reported for brevity, Standard errors in parentheses (clustered by farm for the FE model and robust for the GMM model), * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, N = 12,827

The first column in Table 6 presents the results of our original risk balancing FE regression model based on equation 2. We find no significant evidence that *ceteris paribus* Swiss farmers made strategic changes in financial risk in response to changes in expected business risk. A potential explanation for this finding is that interest rates have been low and stable in Switzerland over the period under consideration (1.93% on average, Table 2). Debt was therefore easily available to Swiss farmers and hence the decision to change the level of financial risk was less driven by changes in business risk as it was not constrained. In line with our expectations from section 4.2, we find a negative relationship with past levels of profitability and a positive relationship with the share of direct payments, land tenure and past levels of liquidity. For area we find a significant negative yet small effect, where we would have expected a positive relationship as larger farmers generally have more access to credit. This suggests that the larger farms in terms of area in our sample are potentially less capital-intensive and hence have lower debt requirements (Larger farms in terms of area have more arable land and usually less animals; making them less capital intensive compared to their smaller counterparts (in terms of area). For age, we find the expected signs for the coefficients that indicate a concave down function, yet the coefficients are low and only significant at 10%.

The second column in Table 6 presents the results of our SUR regression models from equation 3 to 5. The correlation coefficients between the regression errors are low (0.0036, 0.0223 and 0.0702), yet the Breusch-Pagan Lagrange Multiplier test of independence rejects the H_0 that the disturbance covariance matrix is diagonal ($\chi^2(3) = 69.8^{***}$). Hence, our three equations cannot be considered independent and our SUR approach is appropriate as opposed to single equation estimation. Estimating the three equations in a system of regressions on the one hand offers us a gain in efficiency (accordingly, we observe smaller standard errors in the FR equation compared to the estimates of the FE model) and on the other hand allows us to test cross-equation restrictions. We find that expected business risk has a significant influence of the expected direction in each of the three equations and a joint Wald test furthermore confirms that the effect is also jointly significant ($\alpha = 0.01$) across the three equations. However, as we have indications of the presence of heteroskedasticity, we will not further discuss our SUR results and turn to our heteroskedasticity robust GMM estimation results.

The coefficient estimates of our GMM model—presented in the last column of Table 6—are nearly identical to the SUR model estimates (as they should be, the slight differences are due to the different estimation approach of the SUR and GMM methods) yet the standard errors differ as we now take heteroskedasticity into account. A joint Wald test indicates that expected business risk still has a significant ($\alpha = 0.01$) influence across all three equations. However, our GMM results now indicate that expected business risk does not significantly influence financial risk decisions. We do find a significant positive influence on the level of off-farm income attained and a negative influence on consumption levels. The effects are small, however, as the model coefficients suggest that for an increase of 0.10 in expected business risk (a change of one within standard deviation), *ceteris paribus*, off-farm income increases with CHF 219 and consumption decreases with CHF 208.

Although the other explanatory variables in our model are mainly added as control variables and are of secondary interest, we will briefly discuss their role in explaining changes in the dependent variables. In the financial risk equation, we obtain the same coefficients for the additional control variables compared to the FE model and hence will not further discuss them.

In the off-farm income equation we find that having a greater proportion of children (below the age of 16) in the household decreases off-farm income as hypothesized. In the category of farm(er) related control variables, we observe that farm households that have an older farm operator and that have more liquid assets have greater levels of off-farm income. Conversely, farms receiving more direct payments and that have greater levels of farm income attract lower levels of off-farm income, which is in line with literature (Serra, *et al.*, 2005, Ahearn, *et al.*, 2006).

Consumption levels are evidently greater in larger farm families and when the proportion of children below the age of 16 is higher. The farm operator's age, the level of farm income earned and the amount of direct payments received are furthermore found to have a positive impact on changes in consumption.

As a robustness check, the GMM model was rerun for each of the three distinct production regions in Switzerland—valley, hill and mountain—to check whether our results differ between regions. These extra models yielded highly similar results, *i.e.*, coefficients with identical signs and of the same order of magnitude and hence are not reported for brevity. Our main variable of interest, business risk, was only significant in the valley-specific models, however, which most likely pertains to differences in sample size (see Table 5).

6. Conclusions

Farm households have several off-farm buffering strategies at their disposal that allow them to influence the variation in total household income, such as earning off-farm income, smoothing consumption levels, seeking off-farm investments or maintaining liquidity buffers. In this light, household risk balancing behavior refers to strategic changes in household buffering in response to exogenous changes in the expected business risk of the farm. This household-level behavior complements original risk balancing behavior which comprises strategic changes in farm-level financial risk in response to the same exogenous changes in business risk (Gabriel and Baker, 1980).

The main objective of this paper is presenting the first empirical evidence on farm household risk balancing behavior using two methodological approaches. Firstly, we use Flemish FADN data complemented with survey data to construct a psychometric household risk balancing scale and explore what determines the differences in scores for different farm households. We find that the average Flemish farm household tends to exhibit household risk balancing behavior based on four underlying factors: (i) making decisions by the family as a whole, (ii) cutting private consumption in response to setbacks in business performance, (iii) mixing personal and business bank accounts to cover expenses and (iv) the necessity of off-farm income. Factors driving differences in household risk balancing behavior are found to be off-farm activity of the farm operator, the level of household income risk, the percentage of household income gained from off-farm sources, the farm operator's level of risk aversion and the farm's profitability and solvability. Secondly, we use Swiss FADN data to estimate a fixed effects seemingly unrelated regression (SUR) model to analyze how farm households jointly alter their levels of financial risk, off-farm income and consumption. The evidence supports the notion that farm households make strategic farm and off-farm decisions in response to the exogenous changes in expected business risk. The econometric model coefficients suggest that for an increase of 0.10 in expected business risk (a change of one within standard deviation), *ceteris paribus*, off-farm income increases with CHF 219 and consumption decreases with CHF 208.

The results of our empirical study demonstrate that when focusing solely on farm-level analyses, an interesting part of the behavioral risk response of farm households is largely ignored. As important farm household responses are not revealed, the full impact of risk-related policies in the EU (e.g. price stabilization, subsidized insurance schemes, direct payments) cannot be assessed. Therefore, a farm household approach to policy analysis is of great importance (Offutt, 2002), and calls for a broadening of the agricultural statistics collection with household income data (Hill, 2002).

Future research could analyze household risk balancing behavior econometrically in those member states of the EU that collect reliable information on off-farm aspects (e.g. The Netherlands, Vrolijk, *et al.*, 2009). It would be valuable to compare results across countries as there surely are marked differences in off-farm opportunities, risk exposure and the level of government support. Our descriptive results indicate that for most farms, off-farm elements stabilize total household risk by buffering the variation in farm income. However, household risk balancing could potentially work in dual directions as for one quarter of our observations the variation of total household income was greater than the variation in farm income. Future research could therefore look deeper into the incidence of both directions.

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Appendix

In the context of the research project 'business-oriented monitoring and analysis of risk in agriculture', a questionnaire survey was conducted aimed at understanding the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of Flemish farmers. This appendix will elaborate on the design of the survey and elaborate on one survey element that is highly relevant for this study: risk attitude.

Research procedure and survey design

A sequential mixed methodology was adopted to conduct this survey (Cameron, 2009). Mixed methods are aimed at taking advantage of the interplay of qualitative phases (usually in the first stage) and quantitative techniques (e.g. data collection in subsequent stages) and are gaining increased momentum in rural sociology research where personal or psychosocial variables are of interest (e.g. Haque, *et al.*, 2010, Wauters and Mathijs, 2013).

In our first—qualitative—research stage, in-depth interviews were conducted with a sample of Flemish farmers (n = 35) aimed at understanding their perception of uncertainty and shocks in addition to their experience of coping with these shocks. As representativeness was not vital at this phase, we used purposive sampling, a non-random sampling method in which individuals who are expected to present the most useful information are selected (Teddlie and Yu, 2007). The in-depth interviews were structured in order to get an exhaustive overview of their risk experience, yet the use of the word 'risk' was avoided as much as possible to avoid confounding due to the different notion farmers have of the concept of risk (van Winsen, *et al.*, 2013). Instead, questions made reference to 'uncertainties' and 'shocks' occurring on the farm and we further asked them about 'difficulties' for farm management and their 'worries' about the future. Detailed results from this primary qualitative research stage are presented in van Winsen, *et al.* (2013). The relevance of these results for the next quantitative stage is that they allowed us to calibrate the next-stage survey and prevented us from posing overly researcher-driven questions.

The second—quantitative—research stage consisted of a postal questionnaire survey, gauging the risk perception, attitudes towards risk and perceived effectiveness of alternative risk management strategies of a large sample of Flemish farmers (n = 614). Only two aspects of the survey are relevant for this dissertation: (i) the elicitation of risk attitude and (ii) exploring household-level risk management approaches. An elaborate description of the additional survey elements (farmers' risk perception, vision on farming and perceived usefulness of additional risk management strategies) and an analysis thereof is presented in Wauters, *et al.* (2014).

The survey was sent out to the whole Flemish FADN sample (759 farms) in March 2013 in collaboration with the Flemish government. 624 surveys were returned, yet after a first data inspection, 10 surveys were excluded for further analysis due to unreliable scores or more than

25% missing data. The final sample available for analysis thus consists of 614 surveys (response rate 81%) and is considered representative for Flanders.

Risk attitude

Risk attitude was elicited in two ways, namely by (i) direct measurement and (ii) constructing a psychometric measurement scale. The former method involved a simple question where farmers could indicate the extent to which they are willing to take risk on a 5-point scale ranging from 1 (very risk taking) to 5 (very risk averse) (Bard and Barry, 2000). The average score was 3.35 (see Table A1), suggesting that the average Flemish farmer is slightly risk averse.

The second method involved constructing a psychometric risk aversion scale based on nine questions that asked farmers to what extent they agree with statements about risk taking in general. A Likert scale was used ranging from 1 (strongly disagree) to 5 (strongly agree). The following questions were adapted from previous applications in literature (e.g. Bard and Barry, 2000, Pennings and Garcia, 2001, McCarthy and Thompson, 2007):

I do not like taking risky decisions

I able to cope well with financial risk and uncertainty on my farm

I cannot afford to take business risk

I am able to experiment with novel ideas (e.g. new varieties or alternative marketing channel), even though this implies additional risk

I am willing to take financial risks if they increase potential profit

I experience sleepless nights when I did not do my utter best to limit my risk exposure

I postpone investments until they are absolutely crucial

I am usually prudent with regards to taking farm financial decisions (e.g. loans and investments)

I am not afraid to lend a lot of money in order to make a profit-increasing investment

As the items are Likert-type variables, most parametric techniques can be used even in the case of serious deviation from normality (Norman, 2010). All nine items were checked for outliers and found to satisfy normality conditions (skewness and kurtosis statistics between -1 and +1). Based on theoretical foundations, a reflective measurement scale was used as these items are manifestations of the underlying construct 'risk aversion' and a change in risk aversion is believed to cause a change in all nine items of the measurement scale (Edwards and Bagozzi, 2000). The internal consistency of the scale constructed using these questions was considered good with a Chronbach alpha value of 0.73. This allows us to calculate a measure for the latent concept 'risk aversion' as the (unweighted) arithmetic mean of the nine items. The sample average of this scale equals 3.24, which is similar to our direct measure (see Table A1). Both risk aversion measures are significantly and positively correlated with $\rho = 0.48$, which is higher than comparable correlation coefficients in literature comparing alternative measurement methods (Hansson and Lagerkvist, 2012, Maart-Noelck and Musshoff, 2013, Nielsen, *et al.*, 2013).

Table A1 Risk attitude measurement

	Direct measure	Psychometric scale
All farms	3.35 (1.01)	3.24 (0.58)

Size class small	3.60 (0.94)***	3.40 (0.55)***
Size class medium	3.40 (0.70)***	3.26 (0.58)***
Size class large	3.12 (1.04)***	3.12 (0.58)***

Notes: *** denotes significance at 1%

A one-way ANOVA analysis indicated that risk aversion is uniform across different production typologies and hence these differences are not reported here. This is in line with our expectations as risk attitude is a personal trait which gives no reason to assume any differences across production typology *a priori*. We do find a significant difference in risk attitude with regards to different farm size classes (defined based on standard output): small farms are found to be more risk averse than medium sized farms, which in turn are still more risk averse than large farms.

Lastly, two risk aversion variables were derived from the continuous psychometric risk aversion scale: (i) a risk aversion dummy and (iii) a categorical variable. The risk aversion dummy—equal to 1 for risk averse individuals—was constructed by splitting the sample into two equal parts, *i.e.*, a median split (observations equal to the median were classified as risk averse). The risk aversion categorical dummy distinguishes risk loving, risk neutral and risk averse individuals and was analogously defined by splitting the sample into three equal parts, i.e., a tertile split (observations equal to the first and second tertiles were classified as risk neutral). Figure A1 presents the histogram of the continuous risk aversion scale and indicates the median cutoff point of the dummy variable (vertical line) and color codes the three risk attitude classes.

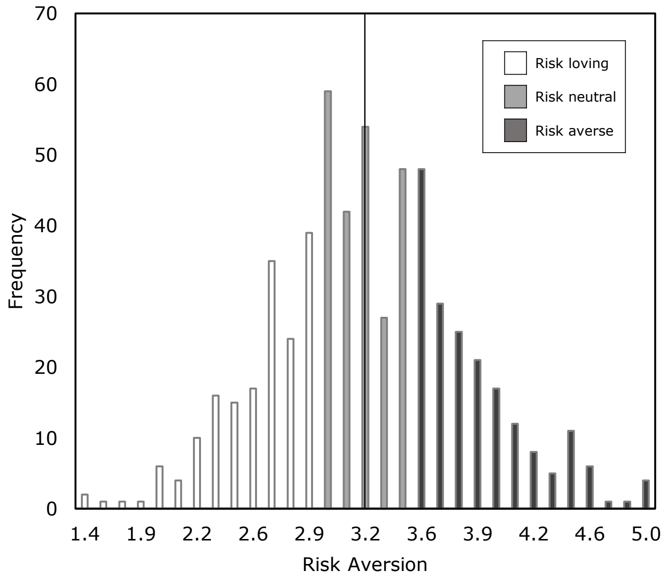

Figure A1 Risk aversion histogram and derived risk aversion categories